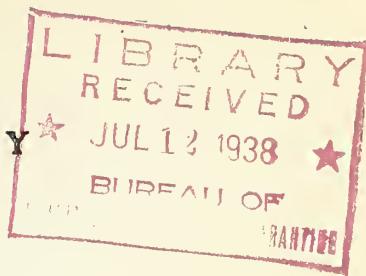


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POPULATION AND HOST PREFERENCES OF JUNE BEETLES

IN SOUTHERN WISCONSIN IN 1935, 1936, AND 1937

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The following is an account of the distribution, flight, habits, and host preferences of species of Phyllophaga in southern Wisconsin,^{2/} based on studies made in 1935, 1936, and 1937. Figure 1 shows the localities in which these studies were conducted. In some of the localities more than one grove was observed.

Studies in 1935

The year 1935 was a year of the flight of the major brood, generally known as "brood A." The first beetle was recorded at Madison on April 26, before work was begun by the Bureau of Entomology and Plant Quarantine. Fairly heavy flights had occurred at Gays Mills by May 12. The spring season was late and the flight prolonged, and heavy flights occurred infrequently on warm nights. Between May 7 and August 7, 49 flights were observed in 14 districts. An area was selected in each district which showed, on general examination, moderate-to-heavy feeding and the presence of a variety of herbs, shrubs, and trees. Groves, largely of bur oaks, showing intense beetle feeding, were avoided because of the scarcity of alternative hosts. Each area was observed from one to many times, as determined by its availability and its value as a collecting ground. Most of the observations were made between 7:30 and 11:30 p.m. Air and soil temperatures were usually recorded at the beginning of the observation period, at the beginning and end of the flights, and at frequent intervals during the observation period.

^{1/}This project is a part of the June beetle investigation being conducted co-operatively by the Division of Cereal and Forage Insect Investigations of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, and the Wisconsin Agricultural Experiment Station through its department of economic entomology. Ritcher made the flight observations at Gays Mills, Wis., in 1935 and Callenbach those in 1936 and 1937. Chamberlin, Fluke, and Seaton made the observations in the other districts for all 3 years.

^{2/}One locality included, Sturgeon Bay, is not in southern Wisconsin.

The heaviest flights of beetles occurred late in May and early in June and, on occasions during this period, beetles concentrated on some kinds of trees, as bur oak, willow, and hickory, in such numbers that samples could be taken by shaking the branches over canvas. A few of these samples were used in attempts to estimate the proportions of various species present in the locality, but the accuracy of these estimates depended on the accuracy of an assumption (based on general observations) that most of the beetle population of the particular area was concentrated on these hosts. In most cases this assumption probably was correct, but at times temperatures and wind so affected the movements of the beetles as to cause them to be widely scattered over a variety of plants and in such numbers that, had they gone to these trees, they would have altered the proportions of the species actually found there. It seems difficult, therefore, to estimate the relative numbers of species present in a given area from the numbers found on any single host. Where many kinds of host plants are considered there are further complications, as nearly all the beetles can be collected from low-growing plants, whereas a relatively small proportion of the beetles on the taller types is accessible.

The relative tenderness of the leaves appears to influence the selection of hosts by various species of beetles. Bur oak seemed to be the preferred host of Phyllophaga hirticula (Knoch) early in the season but later, when the oak leaves had become tough, hickory was preferred. For a considerable period toward the end of the season P. tristis (F.) was not found in the field, and it was concluded that this species had ceased emerging; but at Ripon, Wis., on July 10, large numbers were taken from tender second-growth leaves of bur oaks that had been stripped previously by beetles.

In certain areas beetles fed on species of plants that were not fed upon to any extent in other areas, and this feeding was not dependent on the presence or absence of other hosts. For example, there was in general practically no feeding on boxelder, yet at Gays Mills this host was fed upon, even though other hosts were abundant in the immediate vicinity. Air currents influence the movements of beetles to or from hosts, therefore some beetles may go into the ground in different fields on different mornings and return to different hosts or different sides of the same host on different nights. These habits made it difficult to take any samples closely comparable with others, even in the same area. Temperatures seemed to determine the extent to which beetles fed on low shrubs or trees. On cool nights the beetles did not fly to any extent but issued from the ground and climbed and fed on the nearby shrubs. These observations show that care should be used in attaching much significance to counts made on various plants, no matter how accurate these may be, unless the counting be continued over a long period of time and under a great variety of conditions.

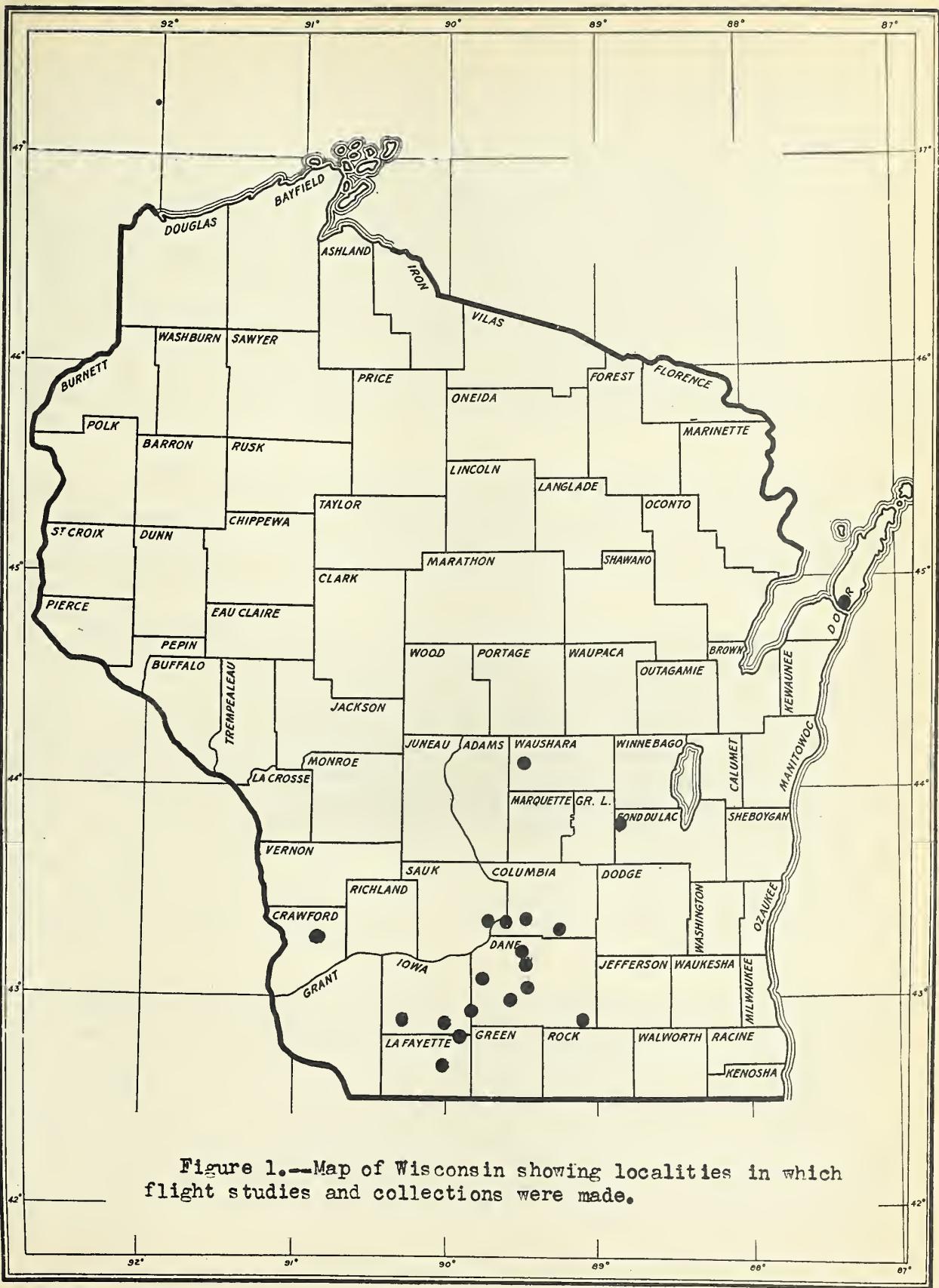


Figure 1.—Map of Wisconsin showing localities in which flight studies and collections were made.

In addition to shaking the limbs of preferred host trees and shrubs over canvas, from two to five collectors picked beetles by hand from all kinds of hosts on which they were found. Attempts were made early in June to devote a definite amount of time to each species of host, but variation in population was found to induce either such dispersion or such concentration of the beetles on their various hosts that the amount of time spent in this way gave a poor idea of host preferences or total populations. After July 1, when beetles became considerably reduced in numbers, an area was entered, its host plants were listed, and all beetles observed within reach were removed from each host. Several persons often collected from different species of hosts simultaneously and often from the same species of host so that the total number of beetles taken should average into figures upon which a fair estimate of the relative abundance of the species of beetles upon certain species of hosts could be based. This method seems to give a definite indication of the relative importance of each species of host in each area as a source of food for the beetles, and for this reason these counts seem particularly valuable.

At present the authors know of no method of estimating accurately the population of the various species of Phyllophaga, based solely on counts of the feeding adults; however, larval counts and counts of adults in the soil made before emergence, in the same areas in which flights are observed, should increase the accuracy of estimates. These additional counts should also be valuable in improving estimates of host preferences.

Flight.--Small flights of beetles occurred when air temperatures were as low as 54° F. One fair-sized flight began at this low temperature near Blue Mounds, Wis., on June 22, 1935, but the soil temperature on this occasion was 60.8°. Air temperatures above 60° are favorable for fairly large flights, and these increased at temperatures of 65° or above. Mating by species other than Phyllophaga tristis was heaviest at 67° to 71°. When, later in the season, higher temperatures occurred, beetles were not so abundant and it could not be determined whether these higher temperatures were more favorable to flight than the lower ones. In May and June many nights were too cold for flight and there were heavy rains which in some cases depressed the temperatures and interfered with flight. Light showers interfered very little with flight, provided the temperatures were high enough. After the first of July temperatures were high enough to permit flight almost every night, but by this time most of the beetles had died.

Population.--A total of 12,053 beetles were taken by hand picking and in a few cases by shaking of branches from determined hosts as given in table 1, which also shows the percentage of the total represented by each species in the collections before July 1, after July 1, and for the entire season. The most abundant species at all times were Phyllophaga rugosa (Melsh.), P. hirticula Knoch, and P. fusca (Froel.), in the order named. P. tristis was fourth in abundance before July 1 but fifth after July 1, and for the whole season was replaced by P. implicita (Horn). These five species made up 98.13 percent of the total number of beetles taken before July 1, 97.90 percent of the total taken after July 1, and 98.09 percent of the total taken during the whole season.

Table 1.—Comparative abundance of various species of
Phyllophaga, brood A, 1935

Species	Before	After	For
	July 1	July 1	Season
	Percent	Percent	Percent
<u>P. rugosa</u> (Melsh.)-----	41.26	50.65	42.34
<u>P. hirticula</u> (Knoch)-----	33.75	24.34	32.66
<u>P. fusca</u> (Froel.)-----	18.72	10.50	17.78
<u>P. tristis</u> (F.)-----	2.40	4.44	2.63
<u>P. implicita</u> (Horn)-----	2.00	7.97	2.68
<u>P. balia</u> (Say)-----	.67	.00	.60
<u>P. ilicis</u> (Knoch)-----	.44	.22	.41
<u>P. futilis</u> (Lec.)-----	.26	.00	.23
<u>P. nitida</u> (Lec.)-----	.15	.50	.19
<u>P. anxia</u> (Lec.)-----	.12	.00	.11
<u>P. drakei</u> (Kby.)-----	.10	1.09	.22
<u>P. spreta</u> (Horn)-----	.07	.00	.06
<u>P. prunina</u> (Lec.)-----	.03	.00	.02
<u>P. marginalis</u> (Lec.)-----	.03	.22	.05
<u>P. crenulata</u> (Froel.)-----	.02	.07	.02
Total beetles-----	10,673	1,380	12,053

Host preferences.—In the 14 districts in which host preferences of the beetles were studied, a great variety of host plants occurred, but the number of species of hosts varied considerably in the different districts. For example, only bur oak, aspen, hickory, elm, and sumac occurred in the grove at Madison, whereas at Waunakee these and 16 other species of hosts were present.^{3/} The districts were as follows: Dane, Waunakee, Madison, Blue Mounds,^{3/} and Verona, in Dane County; Edgerton, in Rock County;^{4/} Blanchardville, in Lafayette County; Sturgeon Bay, in Door County; Ripon, in Fond du Lac County; Merrimack in Sauk County; Mineral Point, Linden, and Hollandale, in Iowa County; and Gays Mills, in Crawford County.

Tables have been made classifying each species according to the host from which it was taken in each collection, but these are too voluminous to be included here. A total of 49 collections from the 14 districts have been consolidated and shown in tables 2 and 3. Table 2 gives all the beetles collected before July 1 and their hosts, and table 3 gives the same for beetles taken after July 1.

It will be noted that there are three entries in most of the spaces in these tables, consisting (reading from the top) of a percentage, a number, and a percentage. The top percentage represents the proportion of the species given at the top of the column which was taken from the host at the left; the number represents the individuals of that species taken from that host; and the lower percentage, the proportion of all individuals of all species found on that host represented by the species at the head of the column. For example, we find in table 2 that 646 individuals of Phyllophaga rugosa were taken from hickory, and that this represented 14.7 percent of the total number of P. rugosa taken and 63.5 percent of the total individuals of all species taken from hickory. Percentages are not shown in cases where they are very low.

Phyllophaga rugosa was taken in all the districts where flight studies were made and, as shown in table 1, it was the most numerous of all species and comprised 42.34 percent of the total beetles taken. It was also the most general feeder and was taken from 35 hosts. It fed heavily on hickory, bur oak, willow, poplar, elm, basswood, and, in the Gays Mills area, on cultivated cherry and boxelder. The first six of the hosts furnished 57.8 percent of the total taken before July 1 and 80.2 percent of the total taken after July 1. None were taken from basswood after July 1.

^{3/} The grove studied was south of Blue Mounds, near the boundary between Dane and Iowa Counties.

^{4/} The grove was north of Edgerton, in Dane County.

Phyllophaga hirticula was also taken in all the localities given, but was very scarce at Gays Mills and not abundant at Madison. Considering the whole of southern Wisconsin, it was next in abundance to P. rugosa and comprised 32.66 percent of the total taken. Although P. hirticula was taken from 22 species of hosts, it does not appear to be so general a feeder as P. rugosa. It fed predominantly on bur oak, hickory, and hazel, those hosts furnishing 85.1 percent of the total taken before July 1 and 74.1 percent of those taken after July 1. It may be noted in the table that hickory furnished 3.9 percent of those taken before July 1 and 51.8 percent of those taken after that date, whereas bur oak furnished 73.8 percent of those taken before July 1 and 3 percent after that date. As stated before, this change in feeding habits seemed to occur while bur oak leaves were becoming tough.

Phyllophaga fusca was also taken in all districts studied. Taking southern Wisconsin as a whole, it was the third species in abundance. It is a rather general feeder and was taken from 25 species of hosts. It fed predominantly on cultivated cherry, bur oak, hickory, hazel, dogwood, poplar, and willow, these hosts furnishing 87.3 percent of the total taken before July 1 and 92.4 percent of the total after that date. It may be noted in comparing tables 2 and 3 that none was taken from cultivated cherry after July 1 and that while only 9.3 percent of the total were taken from dogwood before July 1, 63.4 percent were taken from that host after that date.

Phyllophaga tristis was taken from all districts studied except at Dane and Merrimack. It is, however, known to occur in both places. Considering southern Wisconsin as a whole, it was the fifth species in abundance. It feeds primarily on oak, especially bur oak. Before the first of July 91.8 percent of the total number were taken from bur oak and 3.9 percent from other oaks. After July 1, 82 percent were taken from bur oak and 18 percent from red oaks.

Phyllophaga implicita was fourth in abundance in southern Wisconsin. It was primarily a willow and poplar feeder, but was taken from four other hosts. Before the first of July 86.9 percent of the total were taken from willow and 2.8 percent from poplar. After July 1, 93.6 percent were taken from poplar and 6.4 percent from willow.

Other species.—The remaining 10 species, which together approximated 2 percent of the total, were taken from relatively few hosts. These can be found in tables 2 and 3. Dogwood was the favorite host of Phyllophaga drakei both before and after July 1, and dogwood and hazel were preferred by P. nitida. Most of the P. anxia were taken from willow. The seven specimens of P. spreta were taken from cultivated cherry at Gays Mills.

Any summary such as the foregoing, which gives the total percentages of various beetles collected from different hosts over an entire season, may conceal some of the host preferences because of the variation in population of certain species in different localities. Thus it is possible to collect more specimens of a given species of beetles from an unfavored host, where this species is abundant, than from a favored host where the species is scarce. Much may be gained, therefore, from a careful study of each collection made in each district. It should be emphasized that this was done, and that the estimates of the host preferences and the prevalence of various species based on the individual collections are essentially in agreement with those based on the condensations given in tables 2 and 3.

Table 2.— Beetles of *Phyllophaga* caught before July 1, 1935

Host	<i>P. rugosa</i>	<i>P. hirticula</i>	<i>P. fusca</i>	<i>P. tristis</i>	<i>P. implicita</i>	<i>P. balia</i>	<i>P. illicis</i>	<i>P. futilis</i>	<i>P. drakei</i>	<i>P. nitida</i>	<i>P. crenulata</i>	<i>P. prunina</i>	<i>P. anxia</i>	<i>P. sprata</i>	<i>P. marginalis</i>	Total	
Hickory	14.7%	3.9%	10.9%	.4%		15.3%	2.1%										1018
	6.6%	141	218	1		11	1										
	63.5%	13.8%	21.4%	.1%		1.1%	.1%										
Bur oak	11.5%	73.8%	11.8%	91.8%		1.4%										33.3%	3634
	505	2655	235	235		1										1	
	13.9%	73.0%	6.5%	6.5%		.03%										.03%	
Red oak	.9%	.2%	.6%	2.7%		1.4%											67
	40	7	12	7		1											
	59.7%	10.4%	17.9%	10.4%		1.5%											
White oak	.8%		.5%	.8%		4.2%											47
	34	2	6	2		3											
	72.3%	4.2%	12.7%	4.2%		6.4%											
Black oak	1.9%	.9%	.5%	.4%	2.3%												137
	85	34	9	1		5											
	62.0%	24.8%	6.6%	.7%	3.6%												
Populus sp. inc. Aspen	5.6%	2.9%	12.3%	.4%	2.8%	5.6%	2.1%	3.6%	18.2%								618
	249	107	246	1	6	4	1	1	2								
	40.3%	17.3%	39.8%	.16%	.97%	.6%	.16%	.16%	.3%								
Dogwood	1.7%	.5%	9.3%														296
	74	19	185														
	25.0%	6.4%	62.5%														
Willow	13.9%	.7%	4.7%	.4%	86.9%	1.4%											924
	611	24	94	1	185	1											
	66.1%	2.6%	10.2%	.1%	20.0%	.1%											
Hazel	2.5%	7.1%	2.6%			.5%	9.7%	31.9%	28.6%								465
	110	268	52			1	7	15	8								
	23.7%	57.6%	11.2%			.2%	1.5%	3.2%	1.7%								
Elm	6.2%		1.6%			7.0%	8.3%										328
	273	1	32			15	6										
	83.2%	.3%	9.8%			4.6%	1.8%										
Butternut	3.7%		2.9%														226
	165	1	57														
	73.0%	.4%	25.2%														
Bitternut	1.8%	1.4%															133
	81	49	1														
	60.9%	36.8%	.8%														
Rose	.7%	2.9%															149
	30	106	4														
	20.1%	71.1%	2.7%														
Raspberry	.3%	2.3%															99
	12	84	1			1											
	12.1%	84.8%	1.0%			1.0%											
Gooseberry	1																1
	100.0%																
	2																
Cultivated Apple	2.7%																121
	118		2														
	97.5%		1.7%														
Sunflower																	0
	5.9%																
	262	3	1.1%														
Basswood	97.8%																268
	17.6%	35.7%	2.3%														
	776	713	6			23.6%	12.8%										
Cultivated cherry	50.7%	46.6%	.4%			1.1%	.4%										1530

Table 2 (Cont'd).-Beetles of *Phyllophaga* caught before July 1, 1935

Host	<i>P.</i> <i>rugosa</i>	<i>P.</i> <i>hirticula</i>	<i>P.</i> <i>fusca</i>	<i>P.</i> <i>tristis</i>	<i>P.</i> <i>implicata</i>	<i>P.</i> <i>balia</i>	<i>P.</i> <i>lilicis</i>	<i>P.</i> <i>futilis</i>	<i>P.</i> <i>drakei</i>	<i>P.</i> <i>nitida</i>	<i>P.</i> <i>crenulata</i>	<i>P.</i> <i>prunina</i>	<i>P.</i> <i>anxia</i>	<i>P.</i> <i>spreta</i>	<i>P.</i> <i>marginalis</i>	Total
<u>Walnut</u>	1 50.0%										50.0%					2
<u>Quack grass</u>	.8%															37
	37 100.0%															
<u>Boxelder</u>	1.8% 78 86.7%		.2% 5 5.6%					12.8% 6 6.7%							33.3% 1 1.1%	90
<u>Wild aster</u>	1 100.0%															1
<u>Ash</u>	1 2.9%		1.7% 34 97.1%													35
<u>Balm of Gilead</u>	.3% 13 61.9%		.3% 6 28.6%					2.8% 2 9.5%								21
<u>Ironwood</u>	.9% 41 63.1%		.5% 10 15.4%					13.9% 10 15.4%	8.5% 4 6.2%							65
<u>Plum</u>	2.3% 103 36.8%	2.7% 96 34.3%	3.5% 69 24.6%	.1% 1 .1%				5.6% 4 1.1%	14.9% 7 2.5%							280
<u>Thorn apple</u>	.9% 42 80.8%		3 5.8%					2.8% 2 3.5%	2.1% 1 1.9%	14.3% 4 7.7%						52
<u>Bittersweet</u>	6 100.0%															6
<u>Blackberry</u>	1 100.0%															1
<u>Birch</u>	3 100.0%															3
<u>Serviceberry</u>	1 100.0%															1
<u>Strawberry</u>	1 100.0%															1
<u>Elderberry</u>		1 100.0%														1
<u>Ivy</u>		1 100.0%														1
<u>Black-eyed Susan</u>	3 42.9%							14.3% 4 57.10%			6.2% 1 50.0%					7
<u>Geum</u>	1 50.0%															2
<u>Wild cherry</u>	2 66.7%			.4% 1 33.3%												3
<u>Wild currant</u>											6.2% 1 100.0%					1
Total	4,404	3,600	1,998	256	213	72	47	28	11	16	2	3	13	7	3	10,673

Table 3.-- Beetles of Phyllophaga caught after July 1, 1935

Studies in 1936

Beetles emerging in 1936 in southern Wisconsin belonged to "brood B". Ordinarily this is the smallest of the three broods, but in certain years, such as 1936, the emergence of Phyllophaga tristis, which has a 2-year cycle, has increased the magnitude of the flight of "brood B" considerably. The methods of study were essentially the same as those used in 1935 and insofar as possible beetles were collected from the same groves. Species of beetles other than P. tristis were scarce in 1936, and it was necessary to examine a great many plants in each locality in order to obtain them in any quantity. All plants in each grove were examined carefully and it is believed that a large proportion of the beetles present were actually collected. The scarcity of beetles did not nullify the value of these collections but in some respects was advantageous, especially in the determination of host preferences, since it was not necessary to omit from our calculations the large numbers of beetles which, in seasons of abundance, cannot be collected or counted.

Flight.—The collection of beetles and the study of flight were hindered by the occurrence of many cool nights, which prevented or retarded the emergence of the beetles. Considering the season as a whole, however, the flight of Phyllophaga tristis was very large. Beetles of this species were found in great numbers in various parts of Dane and Lafayette Counties, and many oaks, stripped or partially stripped by them, were observed in these localities. Damage to oaks was reported from Jefferson and Waushara Counties, and specimens were sent in by county agents and other persons from Pepin, Trempealeau, Vernon, Sauk, and Eau Claire Counties.

The first flight of June beetles was observed on May 6 at Gays Mills, but some beetles were taken from beneath leaves early in April.

It was estimated that over 95 percent of the beetles flying belonged to the species Phyllophaga tristis and that over 95 percent of the beetles of this species fed on oak. The flight of P. tristis continued until the end of June but flight of the other species was practically over by June 10.

Phyllophaga tristis flew freely and mated earlier in the season and at lower temperatures than did the other species. Mating was observed at temperatures as low as 52° F. early in the season, but later this temperature was too low for even a small flight. P. tristis usually began issuing from the soil from 10 to 20 minutes earlier in the evening than did the other species. Early in the season emergence began at about 7:30 p.m., but as the length of the days increased emergence began later. With the exception of that by P. tristis very little mating was observed and that observed occurred late in the season.

Species.--Fourteen species of beetles were collected. The number of individual beetles of each species and the percentage of the total that each species comprised are shown in table 4. Beetles of Phyllophaga tristis occurring on oak, which, as indicated earlier, were more numerous than all the others combined, are not included. Of the additional species, P. rugosa was most abundant and comprised 39.66 percent of the total of 1,021 beetles. P. implicita was second in abundance and comprised 17.24 percent of the total. P. fusca, P. futilis, and P. ilicis, respectively, constituted 9.60, 8.52, and 6.66 percent of the total. Together these five species made up 81.69 percent of the total. P. hirticula, which was second in abundance in 1935, was very scarce and comprised only 0.88 percent of the total. Most of the P. futilis beetles were collected at Lamont and most of the P. ilicis beetles at Gays Mills. P. spreta and P. prunina, which were taken in small numbers in 1935, were not obtained in 1936.

Host Preferences.--Table 5 represents a consolidation of all collections made in 1936 and shows the host plants of the various species of beetles and the percentage of the total of each species found on each host, as well as the percentage of the total beetles represented by each species. Phyllophaga tristis beetles on oak, which were many times as numerous as all other species on all hosts, are not included. It should be noted in this table that some species of host plants have been grouped, for example, "poplars except aspen" and "red oak group." On an actual species basis, therefore, the number of host plants would be greater than that indicated.

Table 4. Adults of Phyllophaga Collected in 1936
by species and the percentage of the total
represented by each species

Species	Beetles Number	Percentage of total
<u>P.</u> <u>rugosa</u>	405	39.66
<u>P.</u> <u>implicita</u>	176	17.24
<u>P.</u> <u>fusca</u>	98	9.60
<u>P.</u> <u>tristis</u> ^{1/}	90	8.81
<u>P.</u> <u>futilis</u>	87	8.52
<u>P.</u> <u>ilicis</u>	68	6.66
<u>P.</u> <u>nitida</u>	44	4.31
<u>P.</u> <u>drakei</u>	26	2.55
<u>P.</u> <u>hirticula</u>	9	.88
<u>P.</u> <u>balia</u>	6	.59
<u>P.</u> <u>marginalis</u>	6	.59
<u>P.</u> <u>inversa</u> (Horn)	3	.29
<u>P.</u> <u>anxia</u>	2	.20
<u>P.</u> <u>crenulata</u>	1	.10
Total	1,021	100.00

^{1/} P. tristis beetles on oak not included.

During the season 34 flights were observed in 10 areas as follows: Gays Mills, Crawford County, 16 flights; Black Earth, Dane County, 2 flights; Dane, Dane County, 2 flights; Waunakee, Dane County, 2 flights; Lamont, Lafayette County, 4 flights; Edgerton,^{5/} Rock County, 3 flights; Blue Mounds,^{6/} Dane County, 2 flights; Madison (Lake Forest), Dane County, 1 flight; Madison (Gregg Farm), 1 flight; Hancock, Waushara County, 1 flight.

Phyllophaga rugosa was, relatively speaking, common except at Lamont. According to the classification of the table, it was taken from 21 kinds of host plants. It fed predominantly on cultivated cherry, dogwood, aspen, basswood (linden), white oak, oaks of the red oak group, bur oak, and ironwood, these host plants furnishing 26.91, 9.38, 8.40, 8.15, 7.90, 7.16, 5.93, and 5.68 percent, respectively, and together 79.51 percent of the total. The cultivated cherries, upon which many beetles were found, are at Gays Mills in a commercial planting. Leaving out of consideration for the moment this host, the diversified feeding habits of P. rugosa become apparent, for the maximum percentage from any other host plant was 9.38 percent, from dogwood.

Phyllophaga implicita occurred in all the areas studied and was taken from eight different host plants, willow, aspen, and other species of poplar furnishing 94.32 percent of the total.

Phyllophaga fusca was taken from 15 kinds of plants, butternut, aspen, dogwood, and oaks of the red oak group supplying 26.53, 23.47, 17.35, and 10.20 percent, respectively, and together 77.55 percent of the total.

Phyllophaga futilis was taken from 12 species of host plants, mostly at Lamont. Prickly ash^{7/} supplied 35.63 percent of the total. This host, together with plum, locust, elm, aspen, and hazel, yielded 83.9 percent of the total. Only 6.9 percent of the total was taken from oaks, although these were common in the areas where P. futilis occurred.

The number of Phyllophaga tristis beetles collected from hosts other than oak was very small in comparison with the number observed on the oaks, but 19 species of host plants other than oaks were recorded. Some preference appeared to be shown for birch, dogwood, and aspen.

Studies in 1937

Methods of study in 1937 were essentially the same as those used in 1935 and 1936; however, some of the groves previously used were not suitable for collection in 1937. These were abandoned and others were selected. In the emergence of "brood C" of beetles in 1937, all species, as compared with 1935, were scarce, with the exception of Phyllophaga hirticula, which is normally abundant in this brood in Lafayette and Iowa Counties. On the other hand, all species, with the exception of P. tristis, were more abundant in 1937 than in 1936. In 1938 the flight will be a major one for all species, including P. tristis.

^{5/} The grove studied was north of Edgerton, in Dane County.

^{6/} The grove studied was south of Blue Mounds, near the border of Iowa County.

^{7/} Xanthoxylum americanum.

Table 5.—Beetles of Phyllophaga collected from host plants, 1936 (P. tristis from oaks not included)

Host plants	P. rugosa	P. sapidula	P. fuscata	P. striatula	P. futilis	P. x ilicis	P. nitida	P. drakei	P. hirticula	P. balia	P. marginalis	P. inversa	P. analis	P. crassulata	Total beetles	Percentage of total beetles on host	
Willow	4.44%	59.09%	1.02%	3.33%			2.27%						50%		128	12.54	
	18	104	1	3			1						1	.78%	99.99%		
	14.06%	81.25%		.75%	2.31%		.75%										
Aspen	8.40%	19.89%	23.47%	12.22%	6.90%	5.88%	2.27%	23.08%							120		
	34	35	23	11	6	4	1	6							100%	11.75	
	26.91%	29.17%	19.17%	9.17%	5.00%	3.33%	.83%	5.00%									
Cherry (Cult.)	109	1	1	3											114		
	95.61%	.57%	1.02%	3.33%											100%	11.17	
	95.61%	.88%	.88%	2.63%													
Hazel	3.95%		2.04%	6.67%	6.90%	58.32%	40.91%	23.08%					33.33%				
	16	2	6	6	40	18	6						1		95		
	16.81%	2.11%	6.32%	6.32%	42.11%	18.95%	6.32%						1.05%		100.02%	9.30	
Dogwood	9.38%		17.35%	13.33%	3.45%											87	
	38	17	12	3												99.99%	8.52
	43.67%	19.54%	13.79%	3.45%													
Butternut	4.44%		26.53%	5.56%		10.29%	2.27%										
	18	26	5		7	1										57	
	31.58%	45.61%	8.77%		12.28%	1.75%										99.99%	5.58
Red oak group	7.16%		10.20%	5.75%		13.64%	3.85%						33.33%	33.33%	100%		
	29	10	5		6	1							1		1		
	52.73%	18.18%	9.09%		10.91%	1.82%							1.82%		100.01%	5.39	
Bur oak	5.93%		6.12%	1.15%													
	24	6	1													44	
	54.55%	13.64%	2.27%													100.01%	4.31
Basswood	8.15%			1.11%													
	33	1	1		4	3										41	
	80.40%	2.44%	2.44%		9.76%	7.32%										100.01%	4.02
Prickly ash				10.00%	35.63%											40	
				9	31											100%	3.93
				22.5%	77.5%												
Hickory	3.95%		6.12%	4.44%		11.76%							50.00%	33.33%	33.33%		
	16	6	4		8	3							3	1			
	46.11%	15.79%	10.53%		21.05%								7.89%	2.63%	100%	3.72	
White oak	7.90%	.57%	1.02%			4.41%											
	32	1	1		3											37	
	86.40%	2.70%	2.70%		8.11%											100%	3.62
Poplar (except aspen)	.99%	15.34%	1.02%	2.22%													
	4	27	1	2												34	
	11.76%	79.41%	2.94%	5.88%												99.99%	3.33
Ironwood	5.68%	.57%		2.22%		2.91%	4.55%										
	23	1	2		2	2										30	
	76.67%	3.33%	6.66%		6.66%											99.98%	2.94
Elm	.4%	3.41%	1.02%	2.22%	10.34%	2.27%	3.85%										
	2	6	1	2	9	1	1									22	
	9.09%	27.27%	4.55%	9.09%	40.91%	4.55%	4.55%									100.01%	2.15
Plum	.25%		1.02%	3.33%	13.79%	2.27%	22.22%										
	1	1	3	12	1	1	2									20	
	5%	5%	15%	60%	5%		10%									100%	1.96
Birch				17.78%									33.33%	33.33%			
				16									2	2			
				80%									10%	10%			
Raspberry	.25%			4.44%	3.45%		3.85%										
	1			4	3		1									9	
	11.11%			44.44%	33.33%		11.11%									99.99%	.88
Locust					10.34%											9	
					9											100%	.88
					100%												
Apple (Cult.)	.57%		4.44%														
	1		4													5	
	20%		50%													100%	.49
Walnut				1.11%	1.15%								50%				
				1									1				
				33.33%	33.33%								33.33%				
Crataegus	.74%																
	3															3	
	100%															100%	.29
Sunflower				1.11%													
				1												2	
				50%												100%	.2
Rose				1.02%									3.85%				
				1									1				
				50%									50%				
Gooseberry				1.11%	1.15%												
				1	1												
				50%	50%												
Cherry, wild				1.02%													
				1													
				100%													
Sumac				.25%													
				1													
				100%													
Dogbane				.25%													
				1													
				100%													
Boxelder				.25%													
				1													
				100%													
Total	405	176	98	90	87	68	100%	99.98%	100%	100%	100%	100%	50%	1	1021	100.01%	100.02
	39.57%	17.24%	9.60%	8.81%	8.52%	6.66%	4,31%	2.55%	.88%	.59%	.59%	.59%	.2%	.1%	100	100.01%	

Flight.--Observations on emergence and flight of the beetles agreed essentially with those made in 1935 and 1936. Phyllophaga tristis emerged from 10 to 15 minutes earlier in the evening than did the other species and began flight and mating earlier in the season. P. fusca also began emergence earlier in the season but mated later. P. ilicis appeared late; was found mating but rarely until late in the season; and, as indicated in rearing cages, began oviposition later than other species. Small flights occurred at temperatures in the low 50's but major flights occurred in the 60's and 70's.

There was considerable variation in the duration of the flight period. On some nights the main emergence and flight to host plants was completed within about 5 minutes and on other nights emergence and flight continued slowly but more or less evenly for almost an hour. Soil and air temperatures and wind conditions, as recorded by us, do not explain this behavior.

Species.--Phyllophaga hirticula, the predominating species, was abundant in the Hollandale and Lamont districts but rare at Gays Mills. P. ilicis and P. rugosa were abundant at Gays Mills but less numerous elsewhere. As shown in table 6, the five most common species, P. hirticula, P. fusca, P. rugosa, P. ilicis, and P. implicita, comprised 39.31, 23.48, 18.59, 7.21, and 3.68 percent, respectively, and together made up 92.27 percent of the total. The solitary specimen of P. spreta was taken from butternut at Gays Mills. Of the 7,280 beetles, 106 were taken at Gays Mills and 82 at Blue Mounds between the 1st and 18th of July, inclusive, and all the others before July 1. Because of their scarcity, the beetles taken after July 1 were not classified in a separate table as was the case with those taken in 1935.

Host preferences.--Table 7, which is similar to tables 2, 3, and 5, showing the number of each species of beetles taken from each kind of host plant (or related group of host plants) and the percentage of the total each species comprised, is a consolidation of collections made during 52 flights in 10 districts in southwestern Wisconsin. Thirty-two flights were observed on 30 nights at Gays Mills and 21 flights on 19 nights in the remaining 9 areas. The groves, where observations were made, were near the following towns: Gays Mills, Crawford County; Waunakee, Madison, Blue Mounds,^{8/} Dane County; Edgerton,^{9/} Rock County; Hollandale, Iowa County; Lodi, Poynette, and Leeds, Columbia County.

^{8/} The grove was south of Blue Mounds, near the border of Iowa County.

^{9/} The grove was north of Edgerton, in Dane County.

Table 6.—Adults of Phyllophaga collected in 1937
by species and the percentage of the total represented
by each species

Species	Beetles	Percentage of total
	Number	
<u>P. hirticula</u>	2,862	39.31
<u>P. fusca</u>	1,709	23.48
<u>P. rugosa</u>	1,353	18.59
<u>P. ilicis</u>	525	7.21
<u>P. implicita</u>	268	3.68
<u>P. drakei</u>	227	3.12
<u>P. tristis</u>	121	1.66
<u>P. nitida</u>	92	1.26
<u>P. crenulata</u>	59	.81
<u>P. futilis</u>	30	.41
<u>P. marginalis</u>	16	.22
<u>P. anxia</u>	12	.16
<u>P. prunina</u>	4	.05
<u>P. balia</u>	1	.01
<u>P. spreta</u>	1	.01
Total	7,280	99.98

Table 7.-Beetles of Phyllophaga collected from host plants, 1937

Host Plants	P. hirticula	P. fuscata	P. rugosa	P. nitidula	P. implicata	P. drakei	P. triastis	P. nitidula	P. crenulata	P. fatidica	P. marginalis	P. pruinosa	P. balin	P. spreta	Total	% of total beetles on host		
Hazel	49.30% 1411 64.90%	12.35% 211 9.71%	5.91% 80 3.68%	43.43% 228 10.49%		69.16% 157 7.22%		22.83% .97%	88.14% 21 2.39%	13.33% 4 .18%	37.50% 6 .28%	16.67% 2 .09%	50.00% 2 .09%		2174 100% 100%	29.86%		
Hickory	20.27% 57.43% 580	12.35% 20.89% 211	11.01% 14.75% 14.75%	12.95% 6.73% 6.73%						3.33% 1 .10%	6.25% 1 .10%				1010 100% 100%	13.87%		
Cherry (Cultivated)	.24% 18.61% 7	12.35% 5.17% 35	10.13% 91.73% 621	26.10% 2.28% 19	1.12% 1 .50%			3.26% 3 .49%			6.25% 1 .16%	100% 1 .16%	100% 1 .16%		677 100.01% 100.01%	9.30%		
Butternut	1.15% 8.11% 52.30%	13.52% 16.26% 22.53%	1.01% 1.26% 1.26%	26.10% 2.28% 2.28%	1.12% 1 .49%						6.25% 1 .16%				541 99.99% 99.97%	7.43%		
Bur Oak	2.05% 42.88% 232	15.90% 20.89% 231	2.86% 3.14% 1.7	1.49% 1 .49%							6.25% 1 .16%							
Red Oak Group	8.32% 48.77% 238	8.78% 30.74% 150	2.14% 5.91% 29	.38% 1.33% 2	1.12% 1 .33%	1.32% 2 3	47.11% 3 57	1.09% 1 11.68%	1.69% 1 1	3.33% 1 1	12.50% 2 2	8.33% 1 20%			488 99.97% 99.97%	6.70%		
Aspen	.38% 7.58% 25	8.78% 45.45% 150	5.95% 13.33% 44	.59% 1.33% 7	.30% 35.07% 94						12.50% 1 .41%				330 99.99% 99.99%	4.53%		
Dogwood	.38% 4.51% 52.87%	7.55% 11.29% 129	.57% 8 3	2.00% 1.23% 1.23%	.57% 3.52% 19			20.70% 44.57% 19.26%	.83% 1 41%	10.00% 1 16.80%	6.25% 1 1.23%				244 100% 100%	3.35%		
Willow	.10% 1.62% 3	.59% 5.41 14.59%	2.00% 74.59%	51.49% 1.08%	.88% 1.08%						6.67% 2 1	16.67% 1 1.08%			185 99.99% 99.99%	2.54%		
Walnut	4.58% 80.86% 131	1.35% 14.20% 23	.75% 1.23%	.2% 1 .62%				.83% 1 .62%	1.23% 1 1.23%		6.67% 2 1	25.00% 3 1.85%			162 99.99% 99.99%	2.23%		
Plum	3.70% 75.18% 106	1.40% 17.02% 24	.30% 2.84% 4	.19% .71% 1	.31% .71% 1			.44% 1 .71%	13.33% 4 7						141 100.01% 100.01%	1.94%		
Poplar (Except Aspen)	3.10% 38.66% 53	5.10% 50.36% 69	.19% .73% 1	5.22% 10.22%												137 99.99% 99.99%	1.88%	
Ironwood	1.05% 20.69% 18	4.21% 65.52% 57	1.90% 11.49% 10	.37% 1.15% 1												87 100% 100%	1.19%	
White Oak	2.11% 44.44% 36	2.66% 44.44% 16	.95% 6.17%					2.48% 3 3.70%		3.33% 1 1						81 99.99% 99.99%	1.11%	
Elm	.07% 2.74% 38	1.93% 45.21% 19	1.40% 26.03% 8	1.52% 10.96% 6	2.24% 8.22%	.11% 1.37%					6.67% 2 2.74%	8.33% 1 1.37%			73 100.01% 100.01%	1.00%		
(Basswood) Linden	1.57% 18.64% 45	.23% 59.32% 4	.23% 15.25% 1	.19% 3.39%	5.22% 1.69%							25.00% 1 1.69%				59 99.98% 100%	.81%	
Blackberry	90.00% 1.52% 1.52%	8.00% .23% .23%									3.33% 1 1				50 100% 100%	.69%		
Raspberry	.03% 38.44% 1	.99% 10.26% 17	.81% 5.13% 11	1.33% 5.13%												39 100% 100%	.54%	
Crataegus	.80% 2.75% 1	.05% 47.22% 17														36 100% 100%	.49%	
Gooseberry	76.67% 14.83% 13	3.33% 44.83% 13									13.33% 4 3.33%	8.33% 1 3.33%				30 99.99% 99.99%	.41%	
Cherry (Wild)	1.45% 11.11% 3	.45% 18.52% 5	.75% 70.37% 19	.75% 3.62%							3.33% 2 6.90%	3.33% 1 3.45%				29 100.01% 100.01%	.40%	
Hickory (Pignut)	.28% 11.11% 8	.70% 18.52% 12	.07% 70.37% 1	.38% 3.62%													27 100% 100%	.37%
Birch	14.75% 14.75% 7	52.17% 52.17% 5	4.35% 8.70% 1					1.76% 4 22.26%	1.09% 1 5.56%							23 100% 100%	.32%	
Rose	38.59% 50.00%	27.75% 12.5%	5.56% 37.5%													18 100% 100%	.11%	
Ash										1.65% 2 50.00%	2.17% 2 50.00%						4 100% 100%	.05%
Elderberry											13.33% 4 100.00%							
Ash Prickly											3.33% 2 66.66%							
Grape	73.33% 100.00%															3 99.99% 100%	.04%	
Apple																2 100% 100%	.03%	
Current (Wild)										2.17% 2 100.00%						2 100% 100%	.03%	
Apple (Thorn)																2 100% 100%	.03%	
Sumac																2 100% 100%	.03%	
Weed sp?																1 100% 100%	.01%	
Lead Plant																1 100% 100%	.01%	
Poison Ivy																1 100% 100%	.01%	
Locust																1 100% 100%	.01%	
Total	99.96% 2862	100.01% 1709	99.99% 1353	99.98% 525	99.99% 268	99.98% 227	100.01% 121	99.99% 92	99.98% 59	100.00% 30	100.00% 16	100.00% 12	100.00% 4	100.00% 1	100% 1	7280	99.98% 99.97%	

Phyllophaga hirticula was taken from 21 kinds of plants. Hazel supplied 49.30 percent of the total number of beetles taken. Hickory, oaks of the red oak group, bur oak, and walnut yielded 20.27, 8.32, 8.11, and 4.58 percent, respectively, and together with hazel, 90.58 percent of the total.

Phyllophaga fusca was taken from 27 species of host plants. Butternut, bur oak, hazel, hickory, oaks of the red oak group, aspen, and dogwood supplied 18.61, 13.52, 12.35, 12.35, 8.78, 8.78, and 7.55 percent of the total, respectively, and together 81.94 percent. A diversified feeding habit was indicated in 1937, as in 1935 and 1936. This species did not feed heavily on cultivated cherry, as it did in 1935.

Phyllophaga rugosa was taken from 21 kinds of host plants. Cultivated cherry at Gays Mills supplied 45.90 percent of the total beetles of this species. Hickory, butternut, hazel, poplars other than aspen, ironwood, and aspen yielded 11.01, 10.13, 5.91, 5.10, 4.21, and 3.25 percent of the total, respectively. Together with cherry, these hosts yielded 85.51 percent of the total.

Most of the Phyllophaga ilicis adults were taken at Gays Mills. This species was taken from 17 kinds of host plants, hazel, butternut, hickory, and pignut hickory yielding 43.43, 26.10, 12.95, and 3.62 percent of the total, respectively, and together 86.10 percent.

Phyllophaga implicita was found throughout southwestern Wisconsin but was rather scarce at Gays Mills. It was collected from 11 kinds of host plants. Willow and aspen yielded 51.49 and 35.07 percent, respectively, and together 86.56 percent of the total.

Summary of collections, 1935 to 1937, inclusive

Since the population of various species of June beetles varies among the different broods, it is desirable to summarize the populations of the various species on the 3-year basis.

Table 8 shows the number of each species of beetle taken each year during the period 1935-37, inclusive, the total number of beetles of each species for the 3-year period, and the percentage of the grand total of beetles represented by each species. Phyllophaga rugosa and P. hirticula were taken in about equal numbers, these two species constituting 67.15 percent of the total. P. tristis was probably as abundant as either of these two species, but in 1936, when they were most abundant, they were more numerous in areas where tall oaks predominated; consequently no samples of value could be taken. In 1937 P. ilicis was among the six most abundant species, including P. tristis, but in other years it had not been important.

Table 8.—Beetles of Phyllophaga collected, 1935-37

Species	1935	1936	1937	Total	
	Number	Number	Number	Number	Percent
<u>P. rugosa</u> -----	5,103	405	1,353	6,861	33.71
<u>P. hirticula</u> -----	3,936	9	2,862	6,807	33.44
<u>P. fusca</u> -----	2,143	98	1,709	3,950	19.41
<u>P. implicita</u> -----	323	176	268	767	3.77
<u>P. ilicis</u> -----	50	68	525	643	3.16
<u>P. tristis</u> -----	317	1/90	121	528	2.59
<u>P. drakei</u> -----	26	26	227	279	1.37
<u>P. nitida</u> -----	23	44	92	159	.78
<u>P. futilis</u> -----	28	87	30	145	.71
<u>P. balia</u> -----	72	6	1	79	.39
<u>P. crenulata</u> -----	3	1	59	63	.31
<u>P. marginalis</u> -----	6	6	16	28	.14
<u>P. anxia</u> -----	13	2	12	27	.13
<u>P. spreta</u> -----	7	0	1	8	.04
<u>P. prunina</u> -----	3	0	4	7	.03
<u>P. inversa</u> -----	0	3	0	3	.01
Total -----	12,053	1,021	7,230	20,354	99.99

1/
P. tristis from oaks not included.

The kinds of host plants from which most of the beetles were taken during the 3-year period are shown in table 9. The number of beetles taken from each host in each year, the total taken from each host during the 3-year period, and the percentage of the number of all beetles collected which each host furnished, are also given. Bur oak supplied 21.19 percent of the total and hazel 14.07 percent. The nine species given together supplied 85.55 percent of the total beetles. These records are interesting, as they show the importance of oaks, hickories, poplars, cultivated cherry (when this is in the midst of an infested area), hazel, and dogwood, as hosts.

Table 9.—Principal hosts from 1935 to 1937, inclusive, and the total number of *Phyllophaga* beetles taken from each

Species	1935	1936	1937	Total	
	Number	Number	Number	Number	Percent
Bur oak-----	3,727	44	541	4,312	21.19
Hazel-----	594	95	2,174	2,863	14.07
Hickory-----	1,461	38	1,010	2,509	12.33
Cultivated cherry	1,530	114	677	2,321	11.40
<u>Populus</u> sp.-----	969	154	467	1,590	7.80
Willow-----	977	128	185	1,290	6.34
Butternut-----	239	57	608	904	4.44
Red oak group-----	311	55	488	854	4.20
Dogwood-----	439	87	244	770	3.78
Total, 9 hosts-----	--	--	--	17,413	85.55
Total, all hosts-----	--	--	--	20,354	--

Discussion

These studies are important in their relation to the control of beetles of the genus Phyllophaga by spraying their host plants. From three seasons' work it would appear that the control of the six predominant species in southern Wisconsin would effectually solve the June beetle problem in that region. These species are P. rugosa, P. hirticula, P. fusca, P. tristis, P. implicita, and P. ilicis. The first four of these are considerably more abundant than the last two. P. tristis could apparently be controlled by spraying oaks, especially bur oak, with an effective insecticide; P. hirticula by spraying oaks, especially bur oak, and in some cases hazel and hickory as well; P. implicita by spraying poplars and willows; and P. ilicis by spraying hazel, butternut, and hickory. P. rugosa and P. fusca were found on a large variety of host plants so the spraying of a single species, or even several species, might not materially reduce the numbers of beetles of these species. P. implicita and P. ilicis have rarely, if ever, been encountered as grubs in our sample diggings in cultivated fields and these species may not be important as pests of field crops. Grubs dug from pastures, grain stubble, and corn have chiefly belonged to the species P. rugosa, P. hirticula, P. fusca, and P. tristis, although P. futilis grubs are fairly common in Lafayette County, and the general destruction of adults of these species apparently would solve the grub problem.

There are still many obstacles in the way of spraying trees for control of June beetles. In addition to the fact that no entirely satisfactory insecticide for June beetles has been found, there are many tall trees in southern Wisconsin and spraying these requires the use of an efficient power sprayer equipped with long leads of hose; the host plants are often located in mixed plantings near the tops of hills and sometimes at considerable distances from water; and the groves where beetles tend to concentrate are often scattered. One condition favorable for their destruction, however, is the tendency for maximum defoliation to occur where bur oaks are predominant.